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XLV.—*On the Structure of Astrophiuira, a new and aberrant Genus of Echinodermata.* By W. PERCY SLADEN, F.L.S., F.G.S.

[Plate XX.]

A BRIEF summary of some of the structural peculiarities of this abnormal Echinoderm was published last year (Proc. Roy. Soc. vol. xxvii. p. 456); and subsequently a short note, together with a specific diagnosis of the form, appeared in Carus's 'Zoologischer Anzeiger,' Jahrg. ii. (1879), p. 10.

It is the purpose of the present communication to furnish a description in detail of *Astrophiuira permira*, and to offer such remarks upon its affinities and relationship as are naturally suggested by the investigation. Some delay has intervened in the publication of these observations, prompted chiefly by the desire to obtain a further supply of material, in order to give a more exhaustive description of the anatomy of the organism; but as such a wish may remain unrealized for an indefinite period, it does not now seem desirable to withhold longer the present notes upon this interesting specimen.

Astrophiuira permira, nobis.

General Form.—The body is pentagonal and much depressed, arched above and slightly concave beneath, suggesting, at the first rough glance, a superficial resemblance to the *Asteriscus* type of starfish. The test is entirely covered with

calcareous plates, which are very conspicuous on account of the form and the arrangement which they present: those situated within the central half of the abactinal surface are disposed after the manner of the tessellation of an Ophiuroid disk, whilst the outer portion of the pentagon is occupied by plates which belong exclusively to the radial series, and represent highly modified brachial plates of very abnormal development. The margin of the test is surrounded by a close-set fringe of small compressed spinelets; and the singular appearance of the organism is still further enhanced by the possession of very short rudimentary rays of Ophiuroid type, which extend from the angles of the disk in continuation of the radial series of plates. These diminutive arms, however, are quite insignificant both in size and character, in proportion to the general dimensions of the disk; and, as will be pointed out more fully hereafter, they would seem, when considered in relation to function, to be little more than aborted members.

On the actinal side, the mouth is central and surrounded by ten large mouth-plates, which bear papillæ only; jaws, jaw-plates, and teeth being wanting. In one of the interradii there is a large escutcheon-shaped plate, homologous in its position with the mouth-shield of an Ophiuran; it bears a puncture, and is probably the madreporite; no other shields are present in the remaining four interradii. The ambulacra are largely developed and conspicuous, the tentacle-pores being separated by thin plates and guarded by long lanceolate tentacle-scales. The median line of the radii is occupied by a series of large quadrate plates, which extend from the oral rimæ and represent under arm-plates, or what may perhaps be more correctly spoken of as subambulacral accessory pieces. The extensive triangular interradiial areas are covered with a scaling of small hexagonal plates, which diminish in size as they recede from the actinostome; and the plating terminates at a short distance from the edge of the disk, leaving a portion of the radial plates exposed, in the form of a narrow marginal border.

Description of a Specimen. Abactinal Aspect.—The upper surface of the disk is regularly tessellated with clearly defined symmetrical plates arranged in the following manner. One irregular heptagonal plate, apparently the representative of what would normally be a pentagonal one, occupies the centre, and is encircled by seven slightly elongated plates, irregularly pentagonal and hexagonal, which are the representatives of a normal series of five, the splitting of two of these having given rise to the present irregularity, to which is also due the

modification of the contour of the central plate. These represent the "primary plates" of Ophiuridæ. External to the last-named series of plates follows a ring of ten more or less symmetrical pieces: the five which stand in the median line of the radii are subtriangular or somewhat arrow-headed in outline; and the intermediate or interradianal ones are irregularly pentagonal. Each of the five radial plates, as well as the single central plate, bears a small tubercle of slight elevation. The radial plates have their apex directed outwards and inserted between two large subtriangular plates, which represent the radial shields of a typical Ophiuroid disk. These touch, but only for a very short way on the middle of their inner sides, being again separated by the insertion on their outer margin of the triangular first upper arm-plate. The interradianal space between the shields of two neighbouring rays is occupied by a single large quadrate plate, the outer margin of which is nearly in line with the outer margin of the radial shields. The whole series of plates above described form a circular area which occupies the central half of the pentagonal disk, the remaining outer portion being filled up by extraordinary radial plates, the abnormal development which these attain furnishing a highly remarkable feature in this Echinoderm, as the following description will indicate.

Succeeding to the triangular first upper arm-plate, and situated in the median line of the ray, follow a series of 5-7 rectangular plates, twice as broad as long, and which diminish in size as they approach the margin of the disk, where they become modified in form and pass off, by a gradation of stages, onto the rudimentary ray as the aborted representatives of upper arm-plates. On either side of each upper arm-plate is a long, narrow, band-like lateral plate, representing a side arm-plate, the breadth being equal throughout and corresponding with the length of the upper arm-plate, whence they extend to the margin of the pentagonal disk, each plate in the series being consequently shorter than its more internal predecessor. With the exception of the pair belonging to the first, each side plate is connected with its own proper upper arm-plate, and proceeds from it at right angles to the median line of the ray; this direction, however, is almost immediately changed, and the plate is bent sharply, though only slightly, outwards; whilst corresponding with this flexure in the pseudo-side arm-plates there is a slight downward depression, with a graceful curve, of the whole lateral series, which gives to the median portion of the ray a decidedly raised or gibbous character; and the series as a whole suggests some resemblance in appearance to the body of a trilobite. Although the pseudo-

side arm-plates, which belong to the first upper arm-plate, are separated from it by reason of the development of the radial shields and the position which it occupies, they maintain nevertheless their own relative position in respect to the succeeding side arm-plates, and at the place where their inner margins meet on the edge of the disk they mark the middle of a side of the pentagonal body. In consequence of the angle of direction at which the lateral plates are prolonged from the median line, a large triangular interbrachial space is enclosed between the first side arm-plates of two adjacent radii and the central area of the disk; this is occupied by a single and uniform triangular plate, which is largest and most conspicuous upon the dorsal surface.

The extremity of each side arm-plate which enters into the marginal edge of the pentagonal disk is notched, and bears articulated thereon (normally) three short, stout, compressed spinelets of uniform breadth throughout, their length being equal to or rather greater than the breadth of the side arm-plates. These spines are truncate at the tip or slightly rounded, and so closely placed that they join tightly up to one another laterally, and form a continuous series, which borders the entire margin of the disk. The breadth of the fringe is rather greater at the middle of an interbrachial space than at the extremities, in consequence of the gradual diminution in the length of the spines as they approach the angles. Here and there, in the specimen under notice, the perfect continuity of the series is somewhat interrupted, owing, probably, to accidental breakage and abrasion; occasionally there is an additional spinelet to a side arm-plate, whilst in other cases two or three become merged together. Normally there are about 48-50 spinelets in each interbrachial space.

The manner in which the radial plates of the disk-series become modified in the course of their passage onto the rudimentary arms is very interesting; and the transition into the true side arm-plates of the little rudimentary ray takes place so continuously and intelligibly that no doubt can exist as to the homology of the strangely developed, band-like, lateral plates in the disk with the true Ophiuroid elements of normal form (Pl. XX. fig. 3). It will be observed that the two or three terminal upper arm-plates, which fall within the limits of the pentagonal disk, lose their rectangular shape, and that the first change undergone by the oblong rectangular plate normally consists of a lateral contraction by which the disproportion of breadth to length is reduced; this contraction in the next outward plate is still more developed, its action being greater on the proximal than on the distal margin of

the plate. This gives to the side arm-plates the appearance of resting upon the preceding upper arm-plate, at the same time inducing therein a pentagonal figure.

In the last radial segment included within the pentagonal disk, the upper arm-plate has generally been so much reduced in size that the side arm-plates meet and hold it within the angle which they form, whilst the upper arm-plates, which follow upon the rudimentary ray, have become subtriangular or fan-shaped and quite insignificant in size.

A slight variation, consequent on the irregularity of some of the plates, is noticeable in one of the radii of the present specimen (Pl. XX. fig. 4). This consists of the radial series apparently passing off into the free rudimentary ray before the margin of the disk is reached—a deceptive effect arising from a modification of the last segment included in the disk, by which the side arm-plates and their marginal spinelets remain isolated and form a continuous collar-like rim beneath the ray connecting the lateral fringes of the two neighbouring sides, whilst in all the other rays the series of marginal spines is separated by the presence of the free armlet.

In one of the rays considerable irregularity occurs in consequence of the splitting-up of some of the upper arm-plates and the coalescence of two or more of the side arm-plates, the former circumstance being, to a certain degree, suggestive of the broken character of these plates in *Ophioplocus* and some *Ophiuræ*.

Actinal Aspect.—The mouth is situated in the centre of the under or actinal surface, and is surrounded by ten large plates arranged in pairs, representing side mouth-shields. They are subtriangular or somewhat coultter-shaped, with the small end directed inward; and the two plates of a pair touch one another along their interior half only, the outer portion arching outward towards the radii. These mouth-plates project prominently towards the centre of the actinostome, the mouth-slits being consequently deep and wide; and each mouth-plate (pseudo-side mouth-shield) bears on its outer side three or four short, oblong, flattened mouth-papillæ; and a single, large, semicircular papilla stands at the apex of the pair of mouth-plates (Pl. XX. fig. 5).

A mouth-shield is present in only one of the interbrachial spaces. It is roundly shield-shaped, and is, in all probability, the representative of the madreporiform body—an inference drawn from the fact that this plate bears a raised tubercle punctured with a large pore near one of its outer corners. No jaws (*scutella oralia*), no jaw-plates (*tori angulares*), and no teeth are present.

Extending from the mouth-slits along the median line of the radii are a series of large quadrangular plates, occupying the position of under arm-plates in an Ophiuran (Pl. XX. fig. 6). The first or innermost under arm-plate is much larger than any of the succeeding ones, elongate and somewhat escutcheon-shaped inwardly, but having two broad alæ or extensions produced with a graceful curve from the corners of the outer margin, the whole plate bearing a fanciful resemblance to the gorget of ancient armour. The succeeding under arm-plates are subquadrate, and, being bounded laterally by incurved lines, resemble vertebræ in outline; the number included within the disk is nine or ten, of which the two or three terminal ones diminish very rapidly in breadth, the passage of these into the true under arm-plates of the aborted ray being clearly traceable—a subject to which attention will be directed presently.

The space occupied by the ambulacral system is very considerable, forming in each radius a petaloid area, down the middle of which runs the series of under arm-plates above described (Pl. XX. fig. 6). The entire intermediate space between two neighbouring radii is covered with a tessellated scaly membrane, composed of small, uniform, hexagonal plates. The tessellæ, which form a more or less straight line bordering on the pore-area, diminish in size as they approach the edge of the disk, and at the same time become somewhat rounded in contour; and the plating terminating altogether at a short distance from the margin of the disk, a border is left around the test exposing a portion of the lateral or side arm-plates, in breadth rather greater than the length of the longest spines of the marginal fringe.

Returning now to the ambulacra. A pair of tentacles accompanies each under arm-plate, one on either side; and the neighbouring tentacles or ambulacral feet are separated from those of the next joint by a thin straight partition or septum, which extends somewhat upward into the disk or body in a manner suggestive of the arrangement of the ambulacral plates in certain Asteroids. Owing to the prominence of these septa, which extend between the outer angles of the under arm-plates and the margin of the interradial plating, they have the appearance of cutting up the ambulacral area into square compartments; over these is stretched a thin membranous skin, which is punctured with a large round pore for the passage of the ambulacral tentacle, the orifice being frequently very little less in diameter than the length of the under arm-plate itself (fig. 6). Judging from the appearance of the specimen, the tentacles were, in all

probability, entirely retractile. Each pore is protected by tentacle-scales: one, which is large and lanceolate, is situated on the interradial side of the aperture, and is very frequently found reflected or bent quite backward towards the actinostome; another scale, smaller and more rotund, occurs on the side of the pore adjacent to the under arm-plate, but is often wanting on the pores of the outer portion of the radii. Both of these are unmistakably "scales" in the proper sense of the term, and bear no resemblance whatever to the usual form of tentacle-"papillæ" found in many Ophiurids. In addition to those just described there is frequently a free ovoid-shaped scale present on the outer or aboral portion of the membrane of the tentacular aperture.

The last two or three arm-segments included within the disk are worthy of notice, since they show the gradual stages of modification which the radial series undergo in the course of their passage onto the rudimentary arm. In the last joint but two the breadth of the under arm-plate is very greatly reduced, the proportion to length being less than one half, and the aboral end forms, at the same time, two sloping facets, in consequence of the encroachment of the succeeding pair of side arm-plates, which extend, by the prolongation of their adoral margin, quite up to the median plate, the tentacle-pore being scooped out of the outer margin of the plate itself, as usual in Ophiuridæ. In the last under arm-plate but one the diminution in size becomes still greater, whilst in the segment which follows the side arm-plates meet for more than half their length in the median line, the under arm-plate being reduced to a small subtriangular plate enclosed in a notch on their outer margin; this is the basement joint of the rudimentary arm, and is situated half within and half without the pentagonal disk; the side arm-plates belonging to this segment bear three marginal spines, which are only very slightly modified from those of the marginal fringe. Passing outward to the second joint of the free ray, the under arm-plate is very insignificant, and the arm-spines are present as short, stout, rounded spinelets of true Ophiuroid type, whilst in the third joint the under arm-plate has become quite microscopic and the spines reduced to mere papillæ (Pl. XX. figs. 6, 6 a).

Concurrent with the changes noted above in the plates of the terminal segments of the disk, the pore-areas become very greatly reduced in breadth towards the extremities of the radii; for whilst midway between the centre of the actinostome and the angle of the disk the half pore-area on either side is broader than the median range of under arm-plates, the last

pair or two of pores are scarcely larger than the usual Ophiuroid tentacular orifices. This circumstance, together with the fact that the pores in the neighbourhood of the actinostome are likewise somewhat more circumscribed in breadth than those in the middle of the radius, imparts the petaloid form to the outline of the poriferous area.

It is also of importance to note that there are no tentacle-pores or tentacle-scales present on the rudimentary arms. Owing to the state of preservation of the specimen under consideration, it is impossible to determine what was the length originally attained by these aborted prolongations of the radial system, as they have been unfortunately broken in every case; but from the rapidity with which each succeeding joint diminishes both in size and character from its predecessor, as well as from the rudimentary nature of the parts, the probability would seem very doubtful that these stunted, undeveloped arms were ever of any great extension. As indicating the really diminutive size of the small free rays, it may be mentioned that the first three segments *together* measure little more than one tenth of the diameter of the disk.

The innermost or basal portion of the pore-area is restricted on either side by a narrow elongated plate, which joins up to the *alæ* of the first under arm-plate and is directed downwards towards the side mouth-shield (mouth-plate); it is somewhat sigmoid in shape, thickened at the outer (aboral) end and terminating inwardly in a point, and forms the interradian margin of the first tentacle-pore. This plate I am disposed to regard as the homologue of the Ophiuroid genital scale, although in the present case it is comparatively small and insignificant, being even shorter than the first under arm-plate. There appear to be traces of a slit on the interradian side of this plate, between it and the interradian plating, such as would correspond with one of the *rimæ genitales*; but in the present condition of the specimen it is impossible to speak with certainty on this point.

The communication between the oral cavity and the interradian space is uninterrupted by any calcareous development, so far as I am able to determine without injuring the specimen. By throwing a strongly concentrated ray of light through the test, two small reddish stains, about 1·5 millim. in diameter, are discernible in each interradian area, situated on the sides adjoining the radii, and at about one third the distance between the mouth and the margin: whether, however, these indicate the limits and position of the generative organs cannot be stated decisively without further material; but from the position which they occupy, as well as from the

connexion which is apparently traceable with the genital scales at the base of the radii, it seems not improbable that such may be the case. It would be hazardous, however, even to surmise, with our present information, whether these extended interradiial spaces are utilized mainly as a prolongation of the peritoneal cavity, or whether, on the other hand, they serve more specially the purpose of a marsupium or nidamental cavity—a function not unfrequently called into action amongst Echinoderms.

Internal Arm-skeleton.—As might be expected from the abnormal character of the animal, the internal structure of the radii is both remarkable and peculiar. A form of arm-skeleton or central axis is present, but of a highly modified and aborted description; indeed, from the manner in which light is transmitted through the radial portion of the disk, it would be at once inferred that any internal structures were of the most simple and rudimentary kind, as compared with similar parts in the regular Ophiuroid test. A section was made through one of the radii, between the fourth and fifth under arm-plates; and although the separation of the elements was not effected as satisfactorily as might be, owing to the partial ankylosis of the various ossicles, which made a certain amount of fracture unavoidable and entailed the consequent destruction of some detail, the section is sufficient to show the general features of this portion of the anatomy of *Astrophiura* without risking further damage to the specimen. The body or axis of the arm-skeleton is small and slender, and situated very high in position in the dorsal portion of the ray (figs. 7, 8, *d, e*); in fact the inferior longitudinal notch is situated entirely below, instead of being (in part at least) excavated out of the lower portion of the axis; the alæ or wing-like disk-processes, which in the Ophiuroid arm occupy the whole space between the side arm-plates, are here quite small and rudimentary, being reduced to the diminutive ear-shaped structures marked *b*. The inferior longitudinal neuro-vascular notch is very large and triangular in section, being, in fact, most extraordinary in size, as well as remarkable for its great extension upward.

We now come to a very noteworthy feature in the internal anatomy of the present animal, which is presented by the septa dividing the tentacular compartments. These consist of large, broad, thin plates which join up to the aborted disk-processes of the axis (figs. 7, 8, *a*), and form partitions reaching up to the inner surface of the abactinal wall of the test, their actinal edge forming the prominent straight divisions which are seen, on the superficial aspect of the underside of the

animal, to span across the ambulacral area at each segment. It would seem also that there is occasionally a thickening of the side arm-plate in order to form a junction with, or prolongation of, this plate; but whether such a development is the rule in every segment, I am unable to say, without destroying the specimen. It may be noted that this thickening of two neighbouring side arm-plates is productive of a deep trench or groove between the side arm-plates, following the direction of their line of suture and leading into the main interradiar cavity. Close up to the abactinal wall is the trace of a thin, delicate, arched plate, which forms the boundary of the tentacular cavity (fig. 8, *f*): the extraordinary space occupied by the tentacular pit, to the exclusion (almost absolutely, I believe) of the muscular area, is highly remarkable. This is rendered very striking when a comparison is made of diagrams of the respective parts in *Astrophium* and a typical Ophiuran.

The internal skeleton of the aborted ray-extensions is quite rudimentary and abnormal, the arm-plates being increased to such a thickness as to form almost solid joints, and the communications between the succeeding segments being of the most limited character. This is apparent in the first free segment of radius iv (fig. 9); whilst a little further out upon the ray, in the fourth segment of radius v, the axis has the appearance of a miniature vertebra located in the centre of a disproportionately thick and solid arm-joint (fig. 10).

Skin-appendages.—The plates of the entire test are smooth and naked, there being no trace of pedicellariæ, granules, spinous stumps, or any corresponding developments whatever.

Locality, Preservation, and Colour.—The present example of this Echinoderm was taken at Madagascar, and sent over by a collecting agent along with a number of littoral or shallow-water Asteroids and Echinoids from the same locality. The specimen was simply dried; and its colour in that condition is yellowish white, the marginal fringe of spinelets approaching a light brownish shade, and the actinal or under-side a deeper tint of the same.

Measurements of an Individual.

	millim.
Diameter of pentagonal body.....	14
Length of side of „.....	9.75
Length of a radius.....	8
Diameter of the centro-dorsal “ophiuroid” disk..	8
Radial shields, length to breadth.....	2 : 1.5
Second upper arm-plate, length to breadth.....	0.5 : 1.3

Second side arm-plate, length to breadth	0·5 : 2·75
Mouth-shield (madreporite), length to breadth	0·9 : 0·8
Side mouth-shields, " " ..	1·25 : 0·75
First under arm-plate, " " ..	1·25 : 1·4
Second under arm-plate, " " ..	0·6 : 0·55
Outer margin of a mouth-piece to inner point of opposite first under arm-plate	millim. 2·25
Length of spines in the marginal fringe:—	
a. At the extremity of a side	0·3
β. At the middle of a side	0·75
Length of three segments of rudimentary arm ..	1·3
Breadth of rudimentary arm at base	0·85

General Conclusions.—The following peculiarities in the structure of *Astrophium* suggest themselves as worthy of special attention, in consequence of their important bearing upon the question of the affinities and relationship of the form.

1. The pentagonal, flattened, goniodiscoid body, combining within its area representatives of the whole free radial system as well as of the disk of a typical Ophiuran, presents us with nothing less than the anomaly of an organism having Ophiuroid ray-plates expanded and then consolidated along with their disk into a pentagonal Asteroid form of test. Such a remarkable arrangement of the entire brachial series and abnormal development of the side arm-plates is, so far as I am aware, quite without parallel amongst the Ophiuroidea*, and constitutes a character which I regard as an approach to the structure of the Asteroidea. Although it may be asserted that the resemblance is largely superficial, and that the plates when taken individually are truly Ophiuroid after all, the objection is counterbalanced by the fact that this combination of radial and interradial systems within a common periphery involves morphologically a principle of much higher import than simply outward form, and to which testimony is borne, more or less fully, by each of the following particulars.

* Mr. Theodore Lyman, writing some months ago, has kindly drawn my attention to an interesting species of *Ophiomusium* which he described amongst the material obtained by the 'Challenger' expedition, *O. flabellum*, Lyman, in which a monstrosity occurs in the side arm-plates, the first pair meeting outside the mouth-shield in the median line of the interbrachial space. If I am not mistaken, the same peculiarity is found also in *Ophiozona* (?) *dubia*, Lyman ("Blake" Exped., Bull. Mus. Comp. Zool. vol. v. p. 224, pl. ii. figs. 19-21). It is difficult, however, to look upon these cases as in any way fairly homologous with the extraordinary development present in *Astrophium*, in which we have the series of side arm-plates produced as flat plates extending from the upper arm-plates and occupying entirely a dorsal position upon the test, whilst in the instances cited above the prolongation of the plates occurs on the actinal surface and in a single segment of the ray only. Nevertheless it is a very interesting feature.

2. The limitation of the tentacular pore-system to the disk likewise supports the above view as to the affinities of *Astrophiura*. An approach in the same direction, although in a very different degree, is not wholly unknown in true Ophiurans, the tentacle-pores extending very little, if at all, beyond the disk in *Ophiomusium* and *Ophiolipus*.

3. The extremely rudimentary condition and aborted character of that portion of the radial series which is prolonged beyond the body-disk would seem to give indications of disuse and cessation of function in this area of Ophiuroid organization, followed by a localization of function according to the plan of Asteroid organization. Perhaps, to a certain extent, we find a step in the same direction in *Ophiomusium* and a few of the *Ophioglyphæ*.

4. The extraordinary development of the tentacular or ambulacral system compared with its usual standing in Ophiuran anatomy, together with a most extreme modification of the muscular system characteristic of that group, indicate unequivocally a tendency towards the growth of Asteroid characters; whilst the septa or supplementary plates which form the divisional partitions of the tentacular compartments in *Astrophiura* are not only unknown in Ophiuroidea, but, as far as I am aware, are confined to the Asteroidea. Regarding the aborted axial elements of the radii in the present echinoderm as the natural homologues of the ambulacral plates of Asteroidea, it remains only to determine the equivalents of the septa or accessory plates; and these I propose to identify with the internal connective pieces which occur in *Astropectinidæ* and *Linckiadæ*, and fill in the angle formed by the ambulacral and ventro-lateral plates, and to which M. Viguier (who has recently studied the calcareous test of starfishes) has applied the name of "soutiens ambulacraires." If the view just enunciated be correct, we are presented by this plate in *Astrophiura* with the indications of a stage in the genetic development of Asteroidea all traces of which have gradually passed away in the course of the evolution of the more advanced forms of the group.

It should be mentioned that an approach towards the large size of the cavity for the reception of the tentacle is perhaps to be found in *Ophiomyces frutescosus*, Lyman.

Respecting the under arm-plates, which seem to accord so fully with the homologous plates in Ophiuroidea, it may be remarked that their peculiarity in this instance may be accounted for by the abnormal development of the whole organism, and the consequent action of correlation, rather than as the direct outcome of inheritance or functional utility. The original estimate of the ordinal value of these plates, in conse-

quence of their being elements of structure supposed to be entirely unrepresented in Asteroids, is placed in quite a different light by the statement made by A. Agassiz that homologous plates occur in an early stage of the Asteroid larva, but ultimately become resorbed during the growth of the ambulacra.

5. The prolongation of the peritoneal cavity into the radial portion of the animal is a divergence towards a structure usual in the Asteroid group*.

6. The simple and rudimentary character of the mouth-armature certainly follows much more closely in principle the plan of structure obtaining in Asteroidea than the highly modified and complex organization which is found in most Ophiuroids. In fact simple mouth-plates bearing papillæ only are in *Astrophiuura* the sole representatives of the elaborate apparatus, consisting of side mouth-shields, jaws, jaw-plates, and teeth, which is met with in the latter group.

It may be suggested that the mouth-plates, which are spoken of in the foregoing description as representatives of the side mouth-shields, might with more propriety be styled "jaws," since these latter are the first formed and are the result of the development of the first adambulacral plate, whilst the side mouth-shields are the modification of the second adambulacral plate. A moment's consideration, however, will show that any dogmatic insisting upon such a nomenclature is a mere play on words; for it will be seen that the term which I elected to use, for descriptive purposes only, was that which expressed most clearly the position of the plates in relation to the mouth-shield, as well as their own individual form; whilst the fact of their wanting both jaw-plates and teeth would have rendered the application of the other term, if perhaps somewhat more precise, certainly much more misleading.

7. The aborted character of the axis or internal arm-skeleton is particularly noteworthy, and gives evidence of a divergence from a very characteristic Ophiuroid structure, from which due significance must not be withheld when formulating the affinities of the present animal.

In conclusion, it may be noted here that *Ophiophyllum petilum*, Lyman †, a strangely abnormal Ophiuroid taken during the 'Challenger' expedition, superficially resembles *Astrophiuura* in having a fringe-like border of spines round the margin of the disk: but here the comparison ceases; for they are not homologous with the same appendages in our

* So far as the ovaries are concerned, Mr. Lyman informs me that he thinks he has found some such extension in *Ophiocreas*.

† "Ophiuridæ and Astrophytidæ of 'Challenger' Exped.," Bull. Mus. Comp. Zool. vol. v. p. 130, pl. vii. figs. 179-181.

specimen, which are modified arm-spines belonging to the side arm-plates, whilst those in *Ophiophyllum* are, so far as I am able to judge from the figure alone, simply disk-spinelets attached indiscriminately to radial and interradial plates alike.

Without reviewing in further detail the structural peculiarities of this abnormal Echinoderm, it will be clear that no group of genera or family hitherto known can include a form of such aberrant type within the present limits of definition. *Astrophiuura* consequently stands apart, and, in a classificatory point of view, must be considered as the representative of a family of which it is, as yet, the only member known.

Regarding the serial position which the *Astrophiuuridæ* would occupy amongst Echinodermata in relation to the accepted arbitrary divisions in present use, they will naturally be placed, by logical reasoning from the structure of the present form, intermediate between the Ophiuroidea and Asteroidea. Respecting the affinities of *Astrophiuura*, the conclusion seems inevitable that they apparently point to Ophiuroid ancestry, whilst the modifications from the true Ophiuroid arrangement which are present unquestionably take the direction of the more centralized Asteroid plan of organization, and thus form a step which diminishes the distance of structural difference which has been considered to separate the two orders: upon such grounds *Astrophiuura* has a due claim on the consideration of systematists as an intermediate and connecting form. It is undoubtedly premature, in the present state of our information, to endeavour to indicate absolutely how far *Astrophiuura* bridges over the differences between Asteroids and Ophiuroids; but it is certainly not too much to say that this genus passes very much further over the borderland than any other Echinoderm with which we are at present acquainted.

The following diagnosis will embrace the characters involved in the preceding description:—

Fam. *Astrophiuuridæ*, mihi.

Brachia cum disco ophiurano in corpore pentagonali inclusa. Dentes absunt. Oris armatura simplex et imperfecta. Pori pedum ambulacralium septis angustis ad perpendiculum radii directis disjuncti. Cava interbrachialia perlata.

Astrophiuura permira, gen. et sp. nov.

Corpus pentagonale, depressum, supra convexum, infra paulo concavum, obtectum squamis concinnis et planis, in dimidio interiore more disci ophiurani dispositis, in dimidio exteriori scutella

lateralia brachiorum simulantibus maxime prolatis. Brachia incipientia ab angulis disci producta, series radiales continuantia. In superficie actinali os medium, decem magnis ossiculis oralibus cinctum, prostantibus scutellis adoralibus. Unum scutum buccale adest; dentes, scutella oralia et tori angulares absunt. Papillæ orales ternæ aut quaternæ, cum unâ magnâ, ad angulos oris appositâ.

Series scutorum quadratorum a rimis oris per radios procedunt, scutellis ventralibus prostantibus, et per brachia inchoata producuntur.

Foramina pedum ambulacralium septis angustis disjuncta, permagna, protecta singulâ longâ papillâ ambulacrali ad margines interbrachiales, lanceolatâ et squamæformi, alterâ minore ad partem anteriorem radii juxta scutella brachiorum ventralia positâ. Aræ interbrachiales squamis parvis hexagonalibus obtectæ; marginem appropinquantes decrescunt, relinquentes limbum angustum expositum; disci margine cincto densis spinis brevibus et compressis.

Hab. in mari ad oras insulæ Madagascar.

EXPLANATION OF PLATE XX.

- Fig. 1.* *Astrophium permira*, nobis, abactinal aspect. $\times 6.5$.
Fig. 2. Actinal aspect of the same specimen. $\times 6.5$.
Fig. 3. Brachial series of radius ii, abactinal aspect. $\times 10$.
Fig. 4. Brachial series of radius v, abactinal aspect. $\times 10$.
Fig. 5. Actinostome: mouth-armature. $\times 10$.
Fig. 6. Pore-area and actinal aspect of radius iii. $\times 10$.
Fig. 6 a. Terminal portion of pore-area and actinal aspect of radius ii. $\times 10$.
Fig. 7. Transverse section, showing the proximal extremity of the fifth segment in the brachial disk-series of radius iv. $\times 10$.
Fig. 8. Transverse section, showing the distal extremity of the fourth segment in the brachial disk-series of radius iv. $\times 10$.
Fig. 9. Distal extremity of the first free segment of the rudimentary free arm of radius iv. $\times 20$.
Fig. 10. Distal extremity of the fourth segment of the rudimentary free arm of radius v. $\times 20$.

XLVI.—On two new Isopods (*Arcturus*, *sp.*, and *Tanais*, *sp.*) from New Zealand. By GEORGE M. THOMSON.

[Plate XIX. figs. 1-6.]

THE two new species of Isopods described in this paper represent genera not hitherto found in New Zealand; and they are both somewhat remarkable for their resemblance to, and dissimilarities from, already known species. Both forms were